PREDICTIVE TOOL FOR COST REDUCTION OF SCR INSTALLATIONS (BY OPTIMISING PROCESS OPERATION)

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Introduction

KEMA has a calculation model called NOxVision, by which the performance of SCR installations can be examined. In this way it is possible, only having to take a minimal risk, to investigate if adjustments in the operation or the installation can reduce the operational cost.

The catalyst represents a large part of the yearly SCR cost. This is the consequence of the price of the catalyst and its deactivation in time. As for coal-fired power plants, catalyst's lifetimes were reported to last from 2 up to 7 years. The catalysts' inventory of a 600 MW_e coal-fired power plant can represent a value of 7 M USD. Hence, if the catalyst's lifetime is only slightly increased, it will have a considerable positive effect on the catalyst's yearly cost. The catalyst's lifetime can be increased by choosing the right catalyst replacement strategy and/or by optimising the process conditions so that catalysts can operate more effectively.

The way in which the SCR can be optimised and whether such an optimisation is cost-effective, can be evaluated by means of the calculation model NOxVison, which was developed by KEMA. In this model both the kinetics of the reaction of NO_x with ammonia and the transport from the reactants in the (monolithic) catalyst were fundamentally programmed. Furthermore, the effect of mal-distributions of concentrations, temperature and velocity in the flue gases in the SCR installation, are taken into account. The latter implies that the calculations are installation-specific and that the outcome is highly accurate.

In the next paragraphs the results of this model's application in some practical situations are presented.

1. Cost Reduction by Optimal Catalyst Replacement

The optimal replacement strategy was evaluated for a 600 MW_e coal-fired power plant The SCR system for this power plant was placed in the so-called high-dust position, which is located between the boiler's economiser and the air pre-heater. This means that the flue gas still contains all the fly ash when passing the catalyst. Because the fly ash was completely re-used in building materials, the SCR had to be so effective that the ammonia slip remains below 2 mg/m_0^3.

When different replacement strategies are compared, the use of a fourth layer is the best option here. In general, adding a fourth layer is the best option because this will increase the catalyst's average lifetime. The extra cost as a result of the extra pressure drop is relatively small. However, one should be aware that there are exceptions and that, because of certain limitations or boundary conditions, other strategies may be preferable.

2. Cost Saving in Case of Co-firing Secondary Fuels

In the case of high-dust SCR at coal-fired power plants the amount of poisonous components in the fuel directly affects the catalyst's lifetime. Therefore, there is a real risk of co-firing speeding up the catalyst's deactivation rates resulting in a reduced lifetime of the catalyst.

The progress of the ammonia on fly ash can be accurately calculated and predicted by means of NOxVison. This principle can be used as an early warning for extra deactivation in case of co-firing. The amount of ammonia on fly ash is measured almost daily and presents a cloud of measured points in a graph, which follows the trend-line calculated by NOxVision. If the average value of the frequently measured amount of fly ash will start deviating from the predicted line, it is an indication that something changed in the operation of the SCR. If data validation cannot find any deviation in the normal daily operation, it indicates that the catalyst is deactivating more rapidly than in the old situation.

From the deviated progress of the ammonia on the fly ash, the catalyst's new lifetime can be determined and, if necessary, adaptations in the replacement strategy too. In that case a further economical evaluation has to reveal if the extra deactivation still counterbalances the profits because of co-firing the secondary fuel.

KEMA is working on a fully automated version of NOxVision. One of its capabilities is the early warning in case of an increase in the catalyst's deactivation rate.

3. Cost Reduction by Optimising Flue Gas Flow Conditions

The effect of optimising the flue gas flow conditions was evaluated for a waste incineration plant. The SCR system was installed in the so-called tail-end position, which is just in front of the stack and behind the flue gas clean up.

The feasibility of placing a static mixer was evaluated with NOxVision. The distribution of concentrations, temperature and flue gas velocity in front of the SCR, were taken into account in the calculation model. A parameter study showed that with the static gas mixer the catalyst's lifetime would increase from about 70,000 up to 90,000 hours.

This will delay the catalyst's replacement almost 3 years. However, this is not enough to compensate for the extra cost because of the purchase and installation of the static mixer and the extra energy consumption due to the increased pressure drop. In this case, the use of the static mixer is not interesting from an economic point of view.

4. Cost Optimisation in Case of NO_x Trading

In case of NO_x trading, every extra amount that can be removed is valuable. The SCR system can be tuned to reduce as much NO_x as possible. However, this will increase the ammonia slip and thus reduce the catalyst's lifetime. The question is whether the credits that can be earned with the extra NO_x removal will balance the extra cost because of a reduced average lifetime of the catalyst ? This can be evaluated with the calculation model NOxVision.

An evaluation for a 600 MW_e coal-fired power station at which the NO_x removal efficiency was increased from 80% up to 95% was made. The average NO_x removal cost, based on all the costs involved during a 15-year period, shows that the average cost is slightly smaller at 85% removal than at 80% removal. The increase in cost from 90% to 95% removal is considerable and is a consequence of the high catalyst replacement rate, which is necessary to keep the NO_x removal rate at 95%.

In the Netherlands it is expected that the trading price of NO_x will be between 1,000 and 2,000 USD/ton of NO_x when the trading will be effective, i.e. in 2005. As for the coal-fired power plant in this calculation, it is estimated that the average NO_x removal cost will be more than 1,000 USD/ton at 80% removal efficiency. Depending on the exact trading price, this means that increasing the NO_x removal from 80 to 90% will be economically feasible.

Conclusion

In SCR systems it is often possible to take cost-effective measures to reduce operational cost. Optimisation usually results in an increase of the catalyst's lifetime.

The calculation model NOxVision has proven to be a useful tool to evaluate system improvements, to optimise process operation and to extend the catalyst's lifetime. Because installation-specific characteristics, such as deviation in the concentration at different positions in front of the catalyst, are taken into account, the outcome of the calculations has proven to be accurate.